Claims

What is claimed is:

1. A plasma processing apparatus for processing a substrate, comprising:

a process chamber, defined at least in part by a wall, within which a plasma is ignited and sustained for said processing;

a magnetic array having a plurality of magnetic elements that are disposed around the periphery of said process chamber, said plurality of magnetic elements being configured to produce a magnetic field establishing a plurality of cusp patterns on said wall; and

a device for changing said cusp pattern with respect to said wall connected between the plurality of magnetic elements and the process chamber.

2. The apparatus, as recited in claim 1, further comprising a chuck within the process chamber for supporting the substrate within the process chamber.

3. The apparatus, as recited in claim 2, wherein the magnetic field has an azimuthally symmetric radial gradient.

4. The apparatus, as recited in claim 3, wherein said magnetic elements are permanent magnets.

5. The apparatus, as recited in claim 3, wherein said magnetic elements are electromagnets.

6. The apparatus, as recited in claim 3, wherein said device for changing said cusp pattern continuously changes the cusp pattern on said wall.

7. The apparatus, as recited in claim 3, wherein said device for changing said cusp pattern incrementally changes the cusp pattern on said wall.

8. The apparatus, as recited in claim 3, wherein said device for changing said cusp

pattern comprises a device for moving at least one of said magnetic elements.

9. The apparatus, as recited in claim 8, wherein said device for moving at least one of said magnetic elements comprises a device for moving a plurality of said plurality of magnetic elements individually.

10. The apparatus, as recited in claim 9, wherein said device for moving said plurality said plurality of magnetic elements comprises a device for rotating said plurality of magnetic elements in an alternating pattern.

11. The apparatus, as recited in claim 9, wherein said device for moving said plurality of said plurality of said magnetic elements comprises a device for rotating said magnetic elements in a same direction.

12. The apparatus, as recited in claim 8, wherein said device for moving at least one of said magnetic elements comprises a device for moving said array as a unit relative to said process chamber.

13. The apparatus, as recited in claim 12, wherein said device for moving said magnetic array comprises a device for rotating said array around said chamber.

14. The apparatus, as recited in claim 12, wherein said device for moving said magnetic array comprises a device for moving said array closer and farther away from said chamber.

15. The apparatus, as recited in claim 2, wherein said device for changing said cusp pattern comprises a device for moving at least part of said chamber wall within said magnetic field.

16. The apparatus of claim 15 wherein said device for moving at least part of said chamber wall comprises a device for rotating said chamber wall within said magnetic field.

17. The apparatus, as recited in claim 15, wherein said device for moving at least part of said chamber wall comprises a device for moving a part of the chamber wall that is an inner

chamber wall forming a liner.

18. The apparatus, as recited in claim 2, wherein said device for changing said cusp pattern comprises a device for moving at least part of a flux plate assembly within said magnetic field.

19. A method for controlling a volume of a plasma while processing a substrate in a process chamber, said chamber defined at least in part by a wall, using a plasma enhanced process, comprising:

producing a magnetic field inside said process chamber with a magnetic array, said magnetic field establishing a magnetic cusp pattern on said wall;

shifting said cusp pattern on said wall;

creating and sustaining a plasma in a plasma region inside said process chamber; and

confining said plasma within a volume defined at least in part by a portion of said wall and said magnetic field.

20. The method, as recited in claim 19, further comprising the step of mounting said substrate on a chuck, so that said substrate is within said plasma region.

21. The method, as recited in claim 20, wherein the magnetic field has an azimuthally symmetric radial gradient.

22. The method, as recited in claim 21, wherein the step of producing said magnetic field comprises the step of providing a plurality of magnetic elements that are disposed around said wall, and wherein said step of shifting said cusp pattern comprises the step of moving at least one of said magnetic elements.

23. The method, as recited in claim 22, wherein the step of moving at least one of said magnetic elements, comprises the step of individually rotating a plurality of magnetic elements in alternating directions.

24. The method, as recited in claim 22, wherein the step of moving at least one of said magnetic elements, comprises the step of individually rotating a plurality of magnetic

elements in a same direction.

25. The method, as recited in claim 22, wherein the step of moving at least one of said magnetic elements, comprises moving a plurality of magnetic elements as a single array, which rotates around said chamber.

26. The method, as recited in claim 21, wherein said step of shifting said cusp pattern comprises the step of moving at least part of said chamber wall.

27. The method, as recited in claim 20, wherein said step of shifting said cusp pattern comprises the step of moving at least part of a flux plate assembly.